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INVESTIGATION USING DATA FROM ERTS TO DEVELOP AND IMPLEMENT
UTILIZATION OF LIVING MARINE RESOURCES

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Principal Investigator: William H. Stevenson
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16. Abstract

The primary objective of this experiment is to demonstrate the feasibility of using satellite imagery to determine the availability and distribution of adult Gulf menhaden B. patronus within the Mississippi Sound and adjacent waters. Secondary objectives are: 1) determine the effectiveness and reliability of ERTS and aircraft remote sensing data to provide fisheries-significant coastal oceanographic information, and 2) ascertain the usefulness of these and other resource data for improving resource harvesting and management. Selected oceanographic, meteorological, and biological parameters are being used as indirect indicators of the resource. Synoptic sea-truth, fishery sampling and weather data, as well as photo and thermal IR imagery, have been acquired as data inputs, and a computer program has been developed to manipulate these data according to user requirements. The experiment is producing correlations between satellite, aircraft, fisheries, and environmental sea-truth data. The resulting information is being used to minimize the effort needed for resource distribution studies, and also provide new areas of investigation for satellite and aircraft remote sensing.

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Preface

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applicable to remote sensing as a tool for resource assess-
ment and monitoring.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ABBREVIATIONS AND SYMBOLS

EarthSat	Earth Satellite Corporation
EREP	Earth Resources Experimental Package
ERL	Earth Resources Laboratory (NASA/MTF)
ERTS	Earth Resources Technology Satellite
FEL	Fisheries Engineering Laboratory (NMFS/MTF)
GSFC	Goddard Space Flight Center (NASA/Greenbelt)
JSC	Johnson Space Center (NASA/Houston)
km	Kilometer
MSS	Multispectral Scanner
MTF	Mississippi Test Facility (NASA/Bay St. Louis)
NASA	National Aeronautics and Space Administration
NC130B	NASA Medium Altitude Remote Sensing Aircraft
NFMOA	National Fish Meal and Oil Association
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NP3A	NASA Medium Altitude Remote Sensing Aircraft
PI	Principal Investigator

1.0 INTRODUCTION

This progress report is the fifth in a series under NASA/ERTS-1 Project No. 240, GSFC ID CO 321. This accounting is a Type II report covering the investigative period from January 20 through July 20, 1973. Type I reports were previously submitted on September 20 and November 5, 1972; and June 11, 1973. A combined Type I/Type II report, retitled "Interim Report", covering the period from July 1, 1972 to March 10, 1973 was submitted during June 1973.

The primary objective of this experiment is to demonstrate the feasibility of using satellite imagery to determine the availability and distribution of the adult Gulf menhaden B. patronus within the Mississippi Sound and adjacent waters. Secondary objectives are: (1) Determine the effectiveness and reliability of ERTS and aircraft information, and (2) ascertain the usefulness of these and other resource data for improving resource harvesting and management. Selected oceanographic meteorological, and biological parameters are being used as indirect indicators of the resource.

The study is being conducted through implementation of four sub-experiments categorized as Utilization, Living Marine Resources, Oceanographic, and Aerospace. Synoptic sea-truth, fishery sampling and weather data, as well as photo and thermal IR imagery, have been acquired as data inputs, and a computer program has been developed to manipulate these data according to user requirements.

Participants of this cooperative venture include various Federal, state and local government agencies, universities, and commercial groups. The experiment is producing correlations between satellite, aircraft, fisheries, and environmental sea-truth data. The resulting information is being used to facilitate development of minimum levels of effort required to obtain data for resource distribution studies, and providing insight into areas of investigation applicable to remote sensing as a tool for resource assessment and monitoring.

2.0 PROJECT PARTICIPANTS

2.1 Principal and Co-Investigative

This project is a cooperative venture whose participants originate from various Federal, state, and local government agencies, universities and commercial enterprises. Parent agencies and/or groups and their respective main-line components and/or contractors who are Principal Investigative and Co-Investigative are as follows:

    National Oceanic and Atmospheric Administration (NOAA)
        National Marine Fisheries Service (NMFS)
            Fisheries Engineering Laboratory (FEL)
            Pascagoula Laboratory

    National Aeronautics and Space Administration (NASA)
        Earth Resources Laboratory (ERL-MTF)

    National Fish Meal and Oil Association (NFMOA)
    Earth Satellite Corporation (EarthSat)

2.2 Associated Groups and Agencies

Various groups and agencies who have and are providing assistance in one form or another to the Principal and Co-Investigative elements within the project are as follows:

National Oceanic and Atmospheric Administration (NOAA)
    National Marine Fisheries Service (NMFS)
        Miami Laboratory
        Beaufort Laboratory
    National Environmental Satellite Service (NESS)
    Atlantic Oceanographic and Meteorological Laboratory (AOML)
    National Weather Service (NWS)

National Aeronautics and Space Administration (NASA)
    Johnson Space Center (JSC)
    Goddard Space Flight Center (GSFC)
    Marshall Space Flight Center (MTF)
        Contractor Support

Alabama Department of Conservation
Gulf Coast Research Laboratory (GCRL)
Gulf Universities Research Consortium (GURC)
U.S. Corps of Engineers (Alabama)
Mississippi State University (MSU)

3.0 TEST SITE

The test site selected is the Mississippi Sound and environs (Fig. 1) bounded by coordinates 30°27'N/89°30'W, 30°27'N/87°45'W, 30°00'N/87°45'W, and 30°00'N/89°30'W. The linear dimensions are length: 170 km, width: 51 km, encompassing a total area of 8685 sq. km.

TEST SITE COORDINATES

	LATITUDE	LONGITUDE
A)	30°27'N	89°30'W
B)	30°27'N	87°45'W
C)	30°00'N	87°45'W
D)	30°00'N	89°30'W

SCALE 1:875,000

N.MI. scale: 10 20

KM. scale: 10 20 30 40

TEST SITE DIMENSIONS

LENGTH: 170 KM.
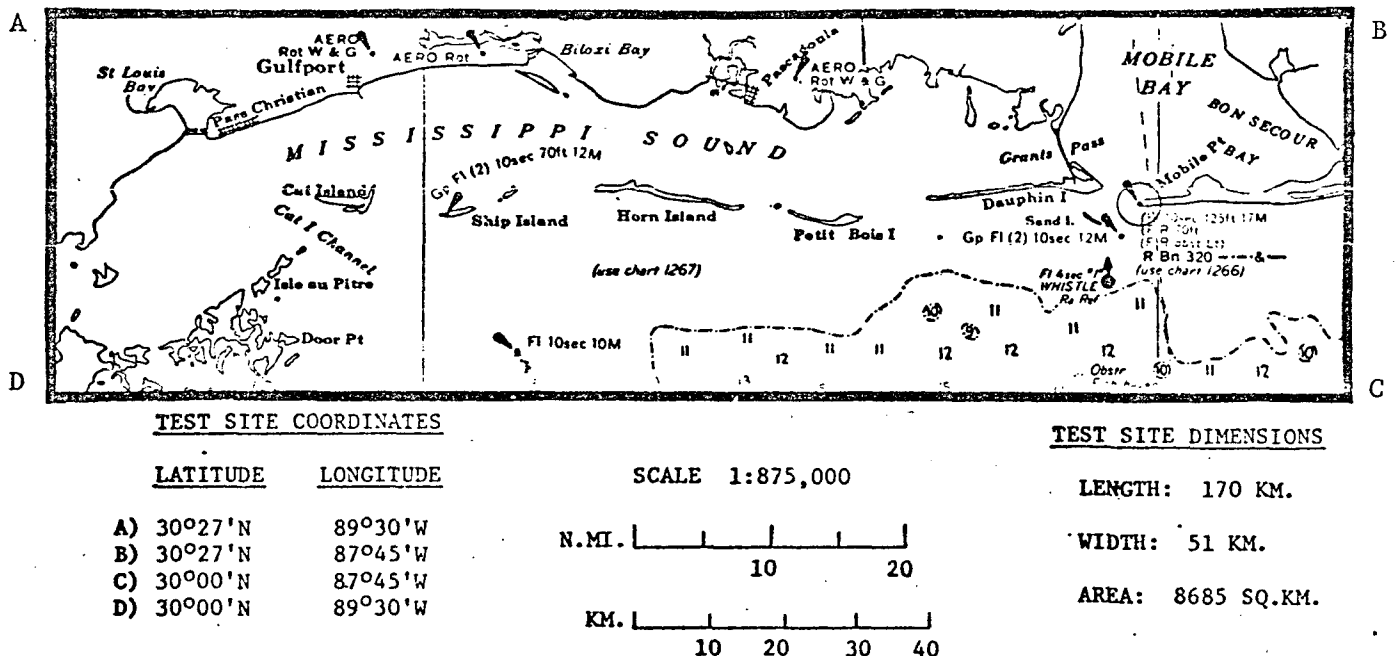WIDTH: 51 KM.
AREA: 8685 SQ.KM.

Figure 1 - Project 240 Test Site

The Sound is an estuarine complex located in the northeastern part of the
Gulf of Mexico, and interfaces with the oceanic waters of the Gulf proper
through a chain of barrier islands situated almost parallel to the coast.
The Sound itself is approximately 17 km. wide by about 110 km. in length
with an average depth of about four meters. Major brackish water embayments
influencing the Sound's water characteristics are Mobile Bay to the east,
Biloxi Bay just west of center to the north, and St. Louis Bay to the
northwest. The Pearl and Pascagoula River systems provide an influx of fresh
water to the Sound. The western part of the Sound is further influenced by
the mixing of water from Lake Pontchartrain located to the northwest of the
test area and interconnected via a body of shallow water referred to as
Lake Borgne (unnamed in the figure) situated immediately east of Cat Island.
The area immediately south of the barrier islands is characterized by near
oceanic water which provides a contrast to the Sound proper.

4.0 REPORTS

   4.1 Published

In addition to the Type I and Type II Progress Reports, and this one, as
previously mentioned in Section 1.0 - INTRODUCTION, a number of other reports
have been generated during the reporting period. These reports have been
either totally or partially supported under terms of Contract No. S-70246-AG.
They are, in order of origination date, as follows:

   1. Maughan, P.M. Investigation to Improve Menhaden Fishery Prediction.
         Feb. 1973, NASA Earth Res. Surv. Prog. Wkly. Abs., 93-73-13,
         Mar. 1973, NASA-CR-130374, 39 p.

   2. Kemmerer, A.J. and Benigno, J.A. Relationships between Remotely
         Sensed Fisheries Distribution Information and Selected Oceanographic
         Parameters in the Mississippi Sound. March 1973, 11 p. Presented
         at the ERTS-1 Symp., 5-9 March 1973, at GSFC, Greenbelt, Md.

   3. Maughan, P.M.; Marmelstein, A.D., and Temple, R. Application of
         the ERTS-1 Imagery to the Harvest Model of the U.S. Menhaden
         Fishery. March 1973, 6 p. Presented at the ERTS-1 Symp.,
         5-9 March 1973, at GSFC, Greenbelt, Md.

   4. Maughan, P.M. Investigation to Improve Menhaden Fishery. April 1973.
         NASA Earth Res. Surv. Prog. Wkly. Abs., 4 June 1973, NASA-CR-131300,
         3 p.

   5. Stevenson, W.H. and Vanselous, T.M. Remote Sensing Data Management
         from a User's Viewpoint. June 1973, 10 p. Presented at the 19th
         Annual Mtg. Amer. Astro. Soc. in Dallas, Tex. AAS Pap. No. 73-152.

The abstract of the paper presented by W. H. Stevenson and T. M. Vanselous, as well as their conclusions are as follows:

Abstract

Incorporation of remote sensing data into a working data bank with diverse inputs and varying user requirements requires thorough management attention and adequate planning, in addition to technical competence. This paper describes the establishment and operation of an experimental data bank in conjunction with the National Marine Fisheries Service's Fisheries Engineering Laboratory's participation in the ERTS-1 Program. After a brief description of the flow of remotely sensed data into a system controlling all data, the established Data Management System is discussed - sources, organization, coordination, data bank operation, and user products.

Conclusions

The data management system was demonstrated to be effective in the performance of the NMFS-FEL ERTS-1 Experiment involving several input sources and varying user requirements. It will be further evaluated under similar conditions during FEL participation in the Skylab and ERTS-B experiments. Agencies and organizations that are planning to incorporate remote sensing data into technical information systems will have to establish and maintain a remote sensing analysis entity as an integral part of the total management information system. At the present time there is little attention being given to this component of the system. Without the technical analysis component remote sensing data cannot be expected to make a significant contribution to the user.

4.2 In review

A technical paper titled "A Summary of Selected Early Results from the ERTS-1 Menhaden Experiment" is now in the process of internal review before submission to NASA as required under the terms of our contract. The authors are Kemmerer, A.J.; Benigno, J.A.; Reese, G.B., and F.C. Minkler. The paper's tentative abstract and a brief on the authors' conclusions have been drafted and are as follows:

Abstract

A 15-month study was initiated in July 1972 to demonstrate the potential of using satellite-acquired environmental data to provide fisheries information. Imagery from the ERTS-1 satellite was used in conjunction with aerial photographically-sensed menhaden distribution information, sea-truth oceanographic measurements, and commercial fishing information from an 8,685-square-kilometer study area in the

northcentral portion of the Gulf of Mexico to demonstrate relationships between selected oceanographic parameters and menhaden distribution, ERTS-1 imagery and menhaden distribution, and ERTS-1 imagery and oceanographic parameters. ERTS-1, MSS Band 5 imagery density levels correlated with photographically-detected menhaden distribution patterns and could be explained based on sea-truth secchi disc transparency and water depth measurements. These two parameters, together with surface salinity, Forel-Ule color, and chlorophyll-a also were found to correlate significantly with menhaden distribution. Eight empirical models were developed which provided menhaden distribution predictions for the study area based on combinations of secchi disc transparency, water depth, surface salinity, and Forel-Ule color measurements.

The feasibility of using satellite-supported environmental sensors to predict fish distribution was demonstrated. ERTS-1, MSS Band 5 imagery was shown to contain density levels which correlated with menhaden distribution. These density levels were further shown to correlate significantly with sea-truth measurements of secchi disc transparency and water depth, two parameters which also correlated significantly with menhaden distribution. Additionally, surface salinity, Forel-Ule color, and chlorophyll-a were found to correlate significantly with menhaden distribution. Independent tests of four oceanographic parameter - menhaden distribution relationships with oceanographic information taken at or near sites of commercial menhaden captures corroborated these relationships. The correlation between chlorophyll-a and menhaden distribution could not be substantiated because of insufficient data.

Eight empirical regression models which predict menhaden distribution in the study area were constructed from combinations of four oceanographic parameters: water depth, secchi disc transparency, surface salinity, and Forel-Ule color. Although the models did not provide particularly precise predictions about menhaden distributions, their predictions nevertheless were statistically significant. The importance of the models is that they demonstrate a potential means or direction through which remotely-sensed oceanographic information can be used to provide menhaden distribution information on a real-time basis. This information could be used by the commercial industry to increase fishing efficiency and by resource managers as an aid to planning assessment surveys.

4.3 ERL Data Reports

The NASA Earth Resources Laboratory at MTF is one of the major participants in Project 240. Prior to becoming a participant, they initiated a study of the Mississippi Sound during the early part of 1971 as part of their remote sensing program. Results of their research efforts were provided to the NMFS/FEL in the form of ERL published internal data reports. These reports became the "backbone" of a historical oceanographic and remote sensing data base for Project 240. During the early part of 1972, the NASA/ERL agreed to participate in Project 240, and to continue providing the necessary sea truth and remote sensing data required under the Project Plan developed for the FEL ERTS-1 Experiment. In support of the project, and as a direct result

of these efforts, the ERL has internally published a number of reports
categorized as to type of field measurement. They are: (1) Surface
Measurements, and (2) Remote Measurements - Light Aircraft. Each report
title bears a date signifying either a major or secondary mission field data
acquisition activity.

1. Surface Measurements

The ERL reports dealing with surface measurements are actually oceanographic
sea truth data compilations listed according to oceanographic station number,
station location, and time of station occupation. In addition to parameter
values acquired by in-situ techniques, specific parameter measurements derived
from laboratory analysis of sea water samples acquired per station, as well
as simultaneously obtained meteorological data, are also listed. The parameter
per station listing includes sea surface temperature, chlorophyll-a , salinity,
water clarity and color, sea state, water depth, surface current speed and
direction, air temperature, relative humidity, wind speed and direction.
Additional information included within each report are surface weather maps,
atmospheric pressure height contours, machine processed radiosonde data;
graphic representations of tidal fluctuations, and maps illustrating remote
sensing aircraft flight lines, oceanographic station locations, sea surface
temperature contours, surface salinity contours, surface chlorophyll distribution
patterns, and water clarity contours. Each report also contains a section
on materials and methods which is further delineated into field and laboratory
procedures. ERL Surface Measurement Reports, generated in support of
Project 240, are as follows:

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
July 6, 1972. Surface Measurements. Report No. 021, Sept. 5,
1972, 32 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
July 11, 19, 25, and August 1, 1972. Surface Measurements.
Report No. 023, Sept. 5, 1972, 32 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
August 7, 1972. Surface Measurements. Report No. 025, Oct. 18,
1972, 25 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
Aug. 25, 1972. Surface Measurements. Report No. 032, Nov. 30,
1972, 36 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
Aug. 15 and 19, and Sept. 7, 1972. Surface Measurements.
Report No. 033, Nov. 30, 1972, 28 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
Sept. 28, 1972. Surface Measurements. Report No. 034, Jan 9,
1973, 31 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
    Sept. 19, Oct. 4 and 18, 1972. Surface Measurements. Report
    No. 037, Jan. 9, 1973, 29 p.

2. Remote Measurements - Light Aircraft

The ERL Remote Measurements - Light Aircraft reports also include those
remote sensing measurements acquired by either the NASA/NC130B or the NP3A
whenever applicable. The reports contain aerial remote sensing information
provided during overflights on either main and/or secondary mission days,
and coincide with the surface measurements reports. The format and contents
of each report varies with the type of aircraft utilized, its sensor
complement, and the data products generated from each specific overflight.
There is, however, a consistency which binds the reports together and this
uniformity is achieved through the use of major content headings apparent in
each report. A data accuracy summary is provided in which the output
accuracy per product of each sensor flown for that particular mission is
discussed and analyzed in terms of system capability, operational constraints,
and data processing and analyzation techniques utilized. A copy of the
flight request is included to provide points of reference on the types of
sensors requested to be flown, operational periods, flight requirements and
constraints, communication requirements, sensor requirements and respective
operational constraints, and target calibration requirements. Another section,
titled "Flight Operations Report" systematically describes the actual flight
and sensor operations, and includes a sub-section on anomalies and/or
malfunctions encountered. Data product information sheets on each sensor
from which a user product is generated are also provided. These sheets
offer the user detailed product information required for data analysis.
Specifically, the sheets provide information on data acquisition start and
stop time, as well as mission date, product format, actual altitude flown
per flight line, scale of imagery, field of view per frame, side and forward
overlap if any, film type and processing particulars, footage available and
a list of frames/time, atmospheric corrections and actual conditions and an
assessment of product quality in conjunction with any anomalies and/or
perturbations per sensor system encountered. Each report also contains a
number of standard products inherent to each particular overflight. These
include flight line and oceanographic station location maps, and actual flight
index maps which allow the user to relate specific sensor product imagery to
sea truth data acquisition locations. Depending on user product requirements,
established in advance of a particular overflight, the report may include a
copy of a specific data product not ordinarily contained within the remote
measurements report. ERL Remote Measurements - Light Aircraft reports,
generated in support of Project 240, are as follows:

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
    July 6, 1972. Remote Measurements - Light Aircraft. Report
    No. 022, Sept. 26, 1972, 23 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
July 11, 1972. Remote Measurements - Light Aircraft. Report
No. 42, Feb. 21, 1973, 26 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
August 15, 1972. Remote Measurements - Light Aircraft. Report
No. 43, Feb. 21, 1973, 27 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
July 25, 1972. Remote Measurements - Light Aircraft. Report
No. 044, March 12, 1973, 26 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
August 7, 1972. Remote Measurements - Light Aircraft. Report
No. 045, March 22, 1973, 26 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
August 1, 1972. Remote Measurements - Light Aircraft. Report
No. 046, March 26, 1973, 26 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
July 19, 1972. Remote Measurements - Light Aircraft. Report
No. 060, May 24, 1973, 14 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
Sept. 7, 1972, Remote Measurements - Light Aircraft. Report
No. 063, May 22, 1972, 24 p.

Sea Remote Sensing Program, Mississippi Sound Remote Sensing Study
29 August 1972. Remote Measurements - Light Aircraft. Report
No. 064, 25 May 1973, 25 p.

5.0 DATA MANAGEMENT

5.1 Processing Operations

Twenty-seven requests from project participants have been received and
processed during the reporting period. These requests included land mass
plots, histogram plots, X/Y point plots, printer tabulations of correlation
coefficients and coefficients of predictive models generated from step-wise
multiple regression programs utilizing data from several banks, various
multiple regressions of commercial fisheries data, low light level image
intensifier transect locations and corrections, class interval grouping of
image intensifier data, printed tabulation and card punching of fish school
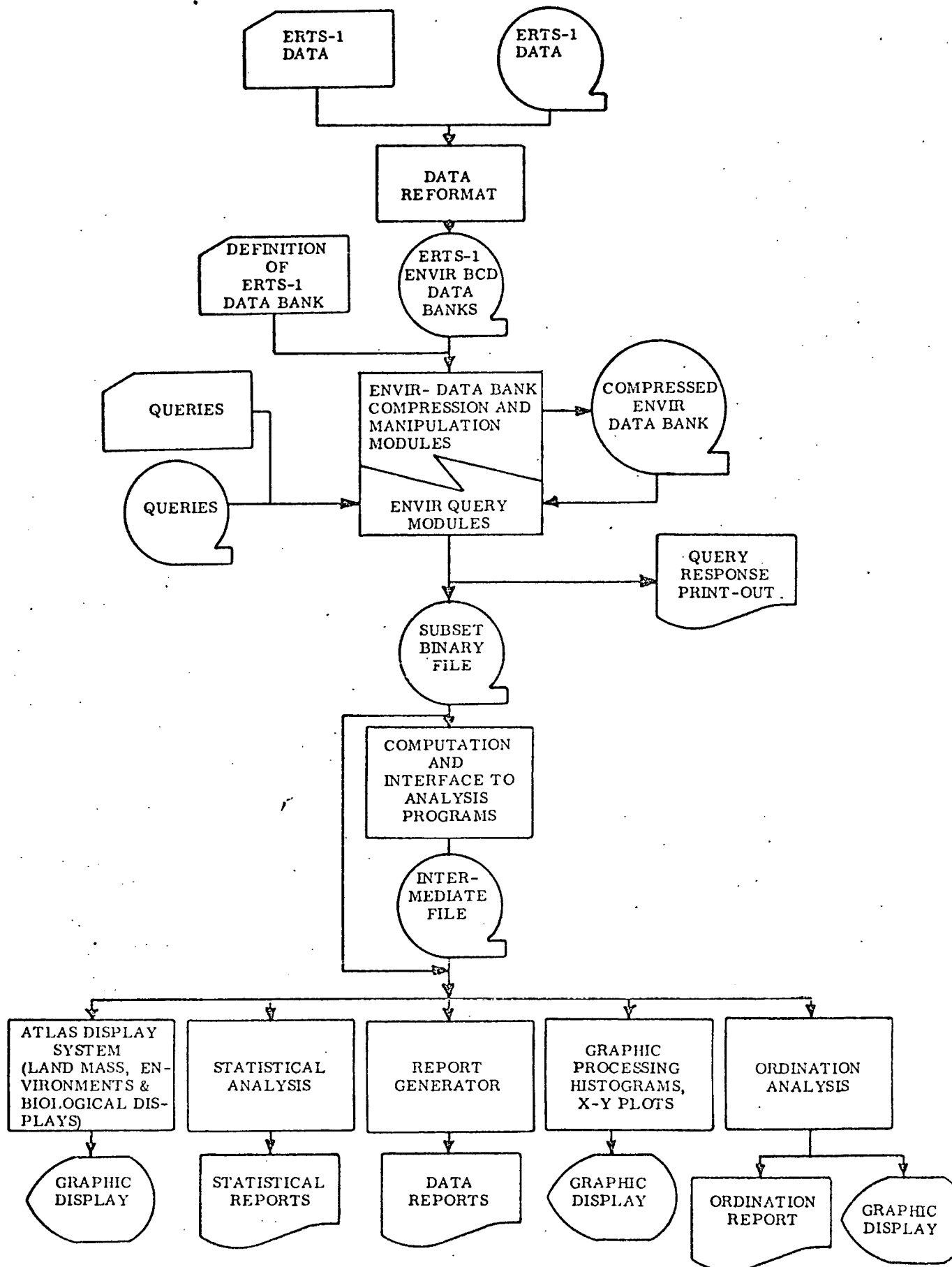and location data.

Figure 2 -ERTS-1 Data Management Software System

5.2 Software Development

In order to attain a high degree of flexibility in the manipulation of multiple sets of oceanographic and fishery parameter data, an Ordination Analysis Program has been developed, checked out, and is now fully operational. The program, as presently configured, has the capability of accepting up to 80 oceanographic stations having up to 10 parameter characteristics per station. The program is unique in that it can be utilized to compare as well as group stations relative to parameter similarity. This characteristic therefore allows a user to stratify data, by a method other than geographic location, as input to the various statistical analysis routines presently available. The system has the capability to ordinate data in up to six dimensions. In other words, tabulations of input values, similarity coefficients, dissimilarity coefficients, and ordination values are provided, as well as one, two, and three dimensional SC-4020 plots of stations relative to the ordination values. The present configuration of the data management software system is illustrated in Figure 2.

5.3 Data Bank Status

There are four components to the data banks, (FEL, ERL, NFMOA/EarthSat, and Pascagoula). They are maintained in a compressed inverted file format. The ERL and NFMOA/EarthSat data banks are now complete, whereas additional information is required to make the FEL and Pascagoula data banks complete. Upon completion of the two remaining banks, all four will then be used to generate a combined compressed inverted data bank which will be utilized in a cross-bank retrieval mode. The major problem encountered has been availability of the computers at the Slidell Computer Facility during the period from May 14 through June 18, 1973. During this time frame, the Facility handled an extremely heavy influx of NASA/Skylab processing which caused week-long delays in individual program runs. This particular problem has now subsided, and is expected to improve in the near future.

6.0 SIGNIFICANT RESULTS

Significant results generated during the reporting period are indicated in the reports in Section 4.0, and the software development in Section 5.0. The feasibility of utilizing ERTS-1 data in conjunction with aerial remote sensing and sea truth information to predict the distribution of menhaden in the Mississippi Sound during a specific time frame has been demonstrated by employing a number of uniquely designed emperical regression models. The construction of these models was made possible through innovative statistical routines specifically developed to meet the stated objectives.

7.0 MEETINGS

Project personnel participated in, or attended, a number of meetings, conferences, symposiums and workshops related directly or indirectly to our ERTS-1 research efforts. Brief summations of these activities follow:

February 1973

A co-investigative member on the project participated in an ERTS-1 Ocean Color
Meeting held at GSFC, Greenbelt, Maryland. One of our inputs was recommendations
for future satellite sensor systems and coverage as well as frequency of data
acquisition.

The FEL hosted a NOAA-wide remote sensing workshop whose theme was "The
Application of Aerospace Remote Sensing to Fisheries Problems". The FEL ERTS-1
project efforts and results to date were specifically addressed. The workshop
was held at MTF, Bay St. Louis, Mississippi.

March 1973

Project personnel participated in the NASA/GSFC sponsored ERTS-1 symposium
held at GSFC, Greenbelt, Maryland. Papers on ERTS-1 data analysis were formally
presented to attendees.

April 1973

On April 30, a meeting among project participants was held to review the
status of the ERTS-1 project. Analysis results to date were presented and
discussed. Most project objectives have been achieved with success much better
than anticipated.

May 1973

The P.I. met with a number of Southeast Asian representatives at a remote
sensing seminar held in Manila, Philippines. Purpose was to instruct and
provide consultation to interested parties on the application of remote sensing
to marine resources.

June 1973

The P.I. participated in, and presented a paper on the FEL/ERTS-1 data management
system to conferees attending the 19th Annual American Astronautical Society
Meeting held in Dallas, Texas.

July 1973

No ERTS-1 meeting activities are scheduled for the month of July.

8.0 FUTURE ACTIVITIES

Projected activities include finalization and submission of the technical paper
identified in Section 4.2. In addition we are continuing to test three
distinct contour routines in an effort to identify the best suitable routine
for purposes of contouring very small sets of data. We anticipate generating
a completed compressed data bank which will contain all the data from the FEL,
ERL, NFMOA/EarthSat and Pascagoula. We will also continue processing computer
analysis requests generated by project participants. The format and organiza-
tion of the final report will be established in order to meet the final report
draft date of September 30, 1973.

9.0 CONCLUSIONS

The use of ERTS-1 data, supported by simultaneously acquired aircraft remote
sensing and sea truth oceanographic and fisheries information, to predict
the distribution of menhaden in the Mississippi Sound during a specific time
frame has been demonstrated. Menhaden distribution patterns, water clarity
and depth have been correlated with specific grey-scale density levels
appearing in band 5 (0.6-0.7 microns) imagery generated by the ERTS-1
Multispectral Scanner system. Menhaden distribution was also shown to
significantly correlate with surface salinity, water color (Forel-Ule technique),
and the surface distribution of chlorophyll-a. The latter correlation is
suspect, however, and could not be verified because of insufficient data.
Models to predict menhaden distribution patterns have been constructed and
tested. Results of these tests indicate that the models can provide near-
precise distribution predictions, and there, have the potential of being
utilized as a tool to increase commercial fishing efforts, as well as provide
an aid to resource managers in planning assessment surveys.

10.0 RECOMMENDATIONS

No recommendations are provided at this time. However, a series of recommenda-
tions are being drafted, and will be an integral part of our final report.